

# Carbon Offsets with Endogenous Environmental Policy

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## Abstract

Interests in obtaining carbon offsets in host countries for Clean Development Mechanism projects may serve as an obstacle to implementing more stringent general environmental policies in the same countries. A relatively lax environmental policy, whereby carbon emissions remain high, can be advantageous for such countries as it leaves them with a higher than otherwise scope for future emissions reductions through Clean Development Mechanism and other offset projects. In this note, the potential to affect the availability of future

Clean Development Mechanism projects is shown to distort environmental and energy policies of Clean Development Mechanism host countries in two ways. Measures to reduce use of fossil energy are weakened. Because this weakens private sector incentives to switch to lower-carbon technology through Clean Development Mechanism projects, host governments then also find it attractive to subsidize this switch, in order to maximize the country's advantage from the Clean Development Mechanism.

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# **Carbon Offsets with Endogenous Environmental Policy**

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## 1. Introduction

The purpose of this note is to illustrate how endogenous economic policy, in particular, environmental tax policy directed toward private domestic actors, combined with the existence of offset markets, can lead to excessive levels of greenhouse gas emissions (or prevent emissions from being reduced) in countries without binding commitments to reduce such emissions. Such increases in emissions work directly against the very purpose of offset markets, including the Clean Development Mechanism (CDM) under the Kyoto Protocol, by eliminating part of the environmental gains achieved through such markets.<sup>1</sup>

The topic of this paper has been subject to some prior discussion, albeit largely in policy contexts. In particular, OECD (2009), on page 131, discusses various adverse side effects of the CDM, two of which are “perverse incentives to raise emissions”, and “reduced incentives for non-Annex I countries to take ambitious mitigation action”. Both arguments reflect the basic idea that the CDM (as well as other similar offset mechanisms) has questionable, possibly counteractive, incentive effects for countries hosting offset projects. The closest analytical connection to this paper is work on endogenous baselines of CDM projects, by Strand and Rosendahl (2009).<sup>2</sup> The difficulty (read: impossibility) of verifying “correct” baselines based on which offsets can be credited in CDM projects (this should in theory be emissions in a counterfactual situation where the CDM does not exist), here gives project hosts incentives to attempt to inflate these baselines, and thus also inflate the value of credits received when the CDM projects are implemented. For discussions of problems with defining, and enforcing, “correct” baselines, and the related methodologies applied to define project

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<sup>1</sup> It must however be stressed that an offset mechanism such as the CDM does not in itself reduce overall global carbon emissions, even when it operates with full efficiency. The reason is that offsets simply give room for increased emissions elsewhere, within a given overall cap. When the offsets promised by accredited CDM projects is not in fact forthcoming, the situation is worse: Global emissions then increase. See Rosendahl and Strand (2009) for further discussion.

<sup>2</sup> For other related analytical work, see Fischer (2004), Akita et al (2007, 2008), and Hagem (2009).

baselines, see e.g. Lazarus, Kartha and Bernow (2000), Greiner and Michaelowa (2003), Schneider (2007), Michaelowa and Purohit (2007), and Wara (2008).

My argument here, while similar to Strand and Rosendahl (2009b), has one major difference of focus. While the strategic response to offset markets in the latter paper was by the *individual firm seeking to implement a CDM project*, it is here by *the government of a country hosting such projects*. Arguably, manipulation of project baselines by individual project hosts is inappropriate as this baseline should, in principle, correspond to the emissions level related to this project, in a (hypothetical) world where the CDM does not exist. In the current model, by contrast, a firm seeking CDM approval is simply responding optimally (and “myopically”) to the policy environment created by the firm’s host government, and in that sense cannot be said to behave strategically. Any “manipulation of baselines” in my model is by host country governments through their general energy and environmental policies. These policies then have effects also for firms that do not seek CDM funding.

In the following the basic model is presented in section 2. In section 3 I study government policy choices, first (in subsection 3.1) optimal policy, then (in subsection 3.2) “technology support” policy given that the environmental tax is zero; and (in subsection 3.3) given that the environmental tax is “high” (at the “optimal” level in the absence of CDM). Section 4 concludes.

## 2. The Model Framework

Consider a representative firm whose output  $Y$  of final goods is given by

$$(1) \quad Y = f(E), f'(E) > 0, f''(E) < 0,$$

where  $E$  is energy consumption of this enterprise, assumed at the outset to consist of fossil fuels. Assume that  $E(t)$  is selected by the firm in period  $t$ , independent of any information about the existence of later CDM opportunities, nor of any related offset markets.<sup>3</sup>

Define  $s_1$  to be a basic (local) excise tax on fossil fuel consumption, set by the firm's host government. Assume a (constant) unit price  $q$  on carbon quotas, established through an offset (CDM) market, that the firm will be able to take advantage of "later" (in period  $t+1$ ). Assume that each firm exists for (exactly) two periods. Define  $h$  as the (constant) unit price of fossil energy, and  $b$  as the price per unit of renewable energy. Assume that renewable energy is subject to an excise tax set by the local country government at rate  $s_2$ . The price paid by firms for renewable energy is then  $b+s_2$ . Both  $s_1$  and  $s_2$  could in principle be negative, i.e., net subsidies.

A formal requirement for CDM approval is that emissions of GHGs be reduced as a direct consequence of the project. Focusing on carbon emissions from fossil energy use in individual firms, one can think of several different ways in which this can be accomplished. I will mention the following:

- a) The firm (or its fossil fuel energy-consuming units) is closed down, and all fossil fuel consumption eliminated.
- b) The firm's fossil energy consumption is reduced, with no other relevant changes.
- c) The firm's energy consumption is unaltered, but its carbon emissions are reduced or eliminated (possibly as a result of a retrofit with carbon capture and sequestration technology).
- d) The firm replaces its fossil energy with (renewable) energy that has lower or no carbon content. This will typically entail a switch to a new energy technology. Overall energy consumption may or may not remain the same.

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<sup>3</sup> As also noted above, here we deviate from the approach taken in Strand and Rosendahl (2009). There, the main issue was *each firm's* strategic adaptation to the possibility of future CDM financing; not as here the strategic adaptation of *government*.

A country which hosts a number of CDM projects, will typically host projects falling in more than one of these categories. I will here consider stylized cases where a “prototype” project in a host country takes one particular among these forms; making it possible to study how a country’s environmental policy can be optimally adapted when this particular project form dominates.

I will devote most attention to projects of category d; although category c projects are principally similar (and could be interpreted via different values of certain parameters). This entails, as noted, the firm shifting all its energy consumption from fossil fuels to renewable energy; I here assume an initial fossil fuel consumption  $E(t)$  in “period  $t$ ”. The final renewable energy consumption in the “next period”,  $B(t+1)$ , is optimized given new parameters. Assume that renewable energy gives rise to no carbon emissions. The reduction in fossil fuel consumption,  $E(t)$  then also corresponds to the reduction in carbon emissions.

Assume that each firm has a given cost  $C$  associated with implementing a change in the fuel structure that makes CDM project approval possible, but that  $C$  varies across firms. Assume also that eventual CDM approval is uncertain at the time when the switch to renewables takes place.<sup>4</sup> No credits are offered to the firm until approval is ascertained.<sup>5</sup> Define  $\alpha$  ( $< 1$ ) as the probability of CDM approval. Possibly,  $\alpha$  may be endogenous, with  $\alpha(t+1) = \alpha(E(t))$  perhaps most likely as an increasing function of  $E(t)$ : the size of the project might count positively toward success probability (e.g. a larger project is more “promising”).<sup>6</sup>

In the model, I assume that each firm does not, in determining the first-period value of  $E(t)$ , take the possibility of future CDM contracting into consideration. Each individual firm is

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<sup>4</sup> It could happen that the EB will rule that the project would have been carried out in any case, in the absence of CDM. CERs will then not be issued for this project according to current standard procedures.

<sup>5</sup> In practice, firms can typically still sell their (not yet certified) CDM projects off to investors in the carbon market, but typically at a lower rate than the full CER value (discounted by a less than unity probability of eventual approval).

<sup>6</sup> The empirical evidence on the relationship between project size and approval probability is unclear, and clearly does not unanimously support our assumption here. In particular, Flues et al (2009) find an opposite (although not significant) relationship, namely that smaller projects seem to have *higher* approval rates. This is ascribed mainly to the administrative approval procedure being simplified for smaller projects.

then assumed not to adapt strategically to the CDM possibility (something that was assumed in Strand and Rosendahl (2009)). Such lack of strategic behavior could have many justifications. One is ignorance of future project possibilities. Another reason (perhaps more logical in the current context) is that any observable strategic behavior may backfire against the firm given that sophisticated mechanisms are used by the EB in evaluating projects.

With  $E(t)$  given, this firm now considers expected profits in the next period, which is the firm's last. Two strategies are available: to retain the initial fossil-fuel production profile; or to replace the fossil fuels with renewables. Define then first the value in expectation from carrying out a project that changes the fuel input from fossil fuels ( $E$ ) to renewables ( $B$ ) (making it possible to seek CDM approval in period  $t+1$ ), by

$$(2) \quad \pi(t+1) = pf(B(t+1)) + (\alpha(E(t))q(t+1)E(t) - (b + s_2)B(t+1) - C,$$

where  $p$  is the (constant) output price of the firm. Assume that  $E(t)$  was determined in the previous period, and is kept constant in period  $t+1$  given no switch of technology. Given that the switch in technology is made in period  $t+1$ , the choice of  $B(t+1)$  is then guided by the following first-order condition:

$$(3) \quad pf'(B(t+1)) = b + s_2.$$

In period  $t$ , profits are given by

$$(4) \quad \pi(t) = pf(E(t)) - hE(t) - s_1E(t)$$

The firm's choice of  $E(t)$  entails maximizing (4) with respect to  $E(t)$ , yielding

$$(5) \quad pf'(E(t)) = h + s_1$$

A key assumption here is that the firm only considers the present period in choosing  $E(t)$ . This assumption can be given at least two alternative interpretations. The first is that the firm simply does not look ahead to the next period; it is sufficiently myopic to only act "one period at the time"; or is not aware of the possibilities of future retrofits. The second, and perhaps more realistic, interpretation is that firms may be aware of these possibilities but refrain from



taking them into consideration in selecting their period  $t$  policies. The reason is that they may fear, and justifiably so, that any such strategic behavior could, potentially, be sanctioned, by the EB or other regulatory bodies, as also argued below.

Tax policy is then shown to affect  $B(t)$ , and  $E(t)$ , as follows:

$$(6) \quad \frac{dB(t)}{ds_2} = \frac{1}{pf''(B(t))}$$

$$(7) \quad \frac{dE(t)}{ds_1} = \frac{1}{pf''(E(t))}.$$

Tax policy here has effect only in the period when it is applied. Note also that  $s_1$  affects  $E$  only, and  $s_2$  affects  $B$  only.

An assumption that may be questioned in the model is that all firms start up with a fossil-fuel technology in period 1. A justification could be that the cost of implementing the renewable energy technology is initially uncertain to the individual start-up, and is high in expectation. This idiosyncratic cost will be revealed to the individual firm in period 1, and the switch turns out to be profitable for only a limited fraction of firms, even when CDM financing is available.

### 3. Solution Implementation with CDM Approval

#### 3.1 Optimal Environmental Taxes

Consider now the firm's choice between sticking to fossil fuels in period  $t+1$ , or then implementing the switch to a technology based on renewable energy. When sticking to fossil fuels, profits would be given by (4), only dated at  $t+1$  (assuming that no variables have changed). When switching to renewables, (2) applies. The difference between (4) and (2) is given by, for a given firm with switching costs  $C$ :

$$(8) \quad \begin{aligned} \Delta\pi(t+1) = & p[f(B(t+1)) - f(E(t+1))] + \alpha(E(t))q(t+1)E(t) \\ & - (b + s_2)B(t+1) + (b + s_1)E(t+1) - C \end{aligned}$$

We now seek to derive the government's optimal strategy for affecting firms' initial fossil energy use for gaining CDM benefits, together with their decisions to switch to renewable energy in their last period of operation. The government is faced with overlapping generations of firms, each existing for two periods, and producing with fossil fuels in the first period. Marginal local environmental damages are assumed to be constant, and given by  $D$  for fossil fuels, and by  $\beta D$  for renewables, where  $\beta (\leq 1)$  indicates the local damage due to renewables relative to damage from fossil fuels. When the renewable energy is fully clean (as, possibly, for wind or solar power), we could have  $\beta = 0$ .<sup>7</sup> We assume that the government in the project host country cares, intrinsically, about  $D$ , but not about the carbon externality related to emissions from fossil fuels. With overlapping generations of firms, the government is assumed to maximize its value function in any one given period (as a steady-state situation). One way to formalize this is to view the government as, effectively, considering the firm's expected two-period emissions profile, with no discounting.<sup>8</sup>

Each firm's individual cost of retrofit,  $C$ , is assumed to be unobservable to the government, which instead faces a perfectly continuous distribution  $G(C)$ , with support  $[0, C_M]$ , where  $C_M$  is "large". Define  $C^*$  as the level of  $C$  that yields equality to zero in (8), i.e., makes this firm exactly indifferent between converting and not converting to renewables. Under our assumptions we then have  $0 < G(C^*) < 1$ . Assume also that the government can subsidize a switch to renewable energy in the amount  $C_0$ . The government's objective function can then be written on the form

$$(9) \quad V = [pf(E) - hE - DE][2 - G(C + C_0)] \\ + [pf(B) - bB - \beta DB + \alpha(E)qE]G(C + C_0) - \int_{C=0}^{C^*+C_0} Cg(C)dC$$

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<sup>7</sup> On the other hand, even wind power is likely to cause some externalities, including aesthetical effects (as documented in several European, including Scandinavian, countries).

<sup>8</sup> To focus on the relationship between policy and firms' decisions, we have in effect simplified the government's welfare maximization problem by ignoring changes in the marginal utility of consumption.

The government is here assumed to attach no value to tax revenue per se: only the effect of taxes on E and B matters. V is maximized with respect to  $s_1$  and  $s_2$  taking into consideration the relationships (6a)-(7a) and the firms' first-order conditions (3) and (5). Note however that  $s_1$  works only on E, while  $s_2$  works only on B.

Consider now maximizing V with respect to E, B, and the additional subsidy parameter  $C_0$  (recognizing that  $s_1$  works only on E, while  $s_2$  works only on B, from (3) and (5)). This may be formulated such that firms pay the retrofit cost  $C^*$ , but that the overall probability of retrofit  $G(C^* + C_0)$  is realized. I derive the following three first-order conditions:

(10)

$$\frac{dV}{dE} = [pf'(E) - h - D](2 - G) + q \frac{d}{dE}(\alpha E)G + [pf(B) - bB - \beta DB + q\alpha E - C^* - C_0 - pf(E) + hE + DE]g(C^* + C_0)[-pf'(E) + h + s_1] = 0$$

(11)

$$\frac{dV}{dB} = [pf'(B) - b - \beta D]G(C^* + C_0) + [pf(B) - (b + \beta D)B + q\alpha E - C^* - C_0 - pf(E) + (h + D)E]g(C^* + C_0)[pf'(B) - b - s_2] = 0$$

$$(12) \quad \frac{dV}{dC_0} = [pf(B) - bB - \beta DB + q\alpha E - C^* - C_0 - pf(E) + hE + DE]g(C^* + C_0) = 0.$$

From (3) and (5), the last square brackets in (10) and (11) are both zero. This simplifies the expressions (10)-(11) substantially. In particular, (11) simply yields

$$(13) \quad s_2 = \beta D.$$

$s_2$  is a standard (local) Pigou tax, to be paid by firms in consuming the renewable energy.

The solution for  $s_1$  is, from (10),

$$(14) \quad s_1 = D - q \frac{d}{dE}(\alpha E) \frac{G(C^* + C_0)}{2 - G(C^* + C_0)}.$$

Note here first that a (local) Pigou tax on fossil fuels would equal D. The optimal fossil fuel tax set by the government here,  $s_1$ , is lower. The additional, negative, term in (14) is

proportional to the offset price  $q$ , and in addition affected by two main factors. The first is related directly to the level of the probability of CDM certification,  $\alpha$ ; and the second to the change in this probability when  $E$  increases,  $\alpha'E$ .<sup>9</sup>

To interpret the expression (14) further, assume for simplicity that  $\alpha$  is a constant. The “CDM-related” component of  $s_1$  is then  $-\alpha[G(C^*+C_0)/(2-G(C^*+C_0))]q$ . Note here that fossil fuel “subsidies” (or under-taxation) are a “blunt” instrument for the government, as fossil fuels are under-taxed regardless of whether or not this contributes to future CDM benefits. Only a fraction  $\alpha G(C^*+C_0)/2$  of overall fossil fuel consumption contributes in this way; the rest, a fraction  $(2-\alpha G(C^*+C_0))/2$ , does not but must still be under-taxed. Note also that the ratio of “incentivized” versus “non-incentivized” fossil fuel consumption (consumption that has any implication for future CDM quotas, versus consumption that does not) equals  $G(C^*+C_0)/(2-G(C^*+C_0))$ . The greater this factor is, the more should the fossil fuel tax be reduced relative to the Pigou tax. The factor  $\alpha$  enters the expression since a “subsidy” to  $E$  in period  $t$  is not fully effective in implementing a higher level of CDM emissions rights in period  $t+1$ , as not all firms who will receive such subsidies, actually will be able to take advantage of the subsidy through future CDM quotas.

From (12),  $C_0 = (D-s_1)E$ , which using (14) can be written as

$$(15) \quad C_0 = q \frac{d}{dE} (\alpha E) \frac{G(C^*+C_0)}{2-G(C^*+C_0)} E.$$

Thus the government’s optimal policy includes the provision of a subsidy  $C_0$  to firms’ retrofit costs. This subsidy constitutes the (negative value of the) last expression in (14), multiplied by  $E$ . It is thus greater when the tax  $s_1$  on fossil-fuel energy is lower. Intuitively, a lower tax on fossil fuels has two separate effects on firms that may seek CDM financing. The first effect, emphasized here, is to increase firms’ “baseline” fossil fuel consumption and thus

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<sup>9</sup> As noted above, in footnote 6, this latter scale effect could in principle be negative, thus offsetting parts of the former effect.

carbon emissions in period  $t$ , against which CDM crediting can be made in the following period  $t+1$ . But the resulting under-pricing of fossil fuels has a second effect which is less desirable from the point of view of the host government: it makes producing on the basis of fossil fuels “too profitable”, so that the switch to production based on renewable energy in the next period not sufficiently profitable. The host government counteracts this effect by a subsidy to the renewable energy conversion, thus reducing firms’ retrofit costs by  $C_0$ .

The optimal policy consequently consists of *a combination of a subsidy to the renewable energy retrofit, together with an environmental tax on energy use in period 1 which is below its standard Pigou level.*

Note that the policy distortion (the deviation of the government’s carbon tax away from the Pigou level, combined with the subsidy to the renewable energy production) can be viewed as one single distortion, namely a downwardly distorted fossil fuel tax which leads to excessive consumption of fossil fuels. But this subsidy has an unwanted effect, as it makes the fossil fuel technology excessively profitable also in the second period, when it is desirable (from the point of view of the government) that the firm switches to the renewable technology. The host government counteracts this additional distortion by subsidizing the renewables switch directly.

Alternatively to the derivations based on (10)-(12), one may study cases where no subsidy is paid to retrofit investments, which leads to a constrained optimal solution for  $s_1$  and  $s_2$ . The solution is then, for  $s_1$  and  $s_2$ , essentially identical to that derived above, and will be based on (10)-(11) only. The only main difference is that the fraction of firms making the transition to renewable energy,  $G(C^* + C_0)$ , now is smaller.

What can one say about the overall effect of existence of the CDM on fossil fuel consumption, and carbon emissions? As a point of reference, assume that in the absence of the

CDM, the tax on fossil fuels would have been Pigouvian.<sup>10</sup> There are then two effects of the CDM on overall carbon emissions in this economy: first, it induces a fraction  $G(C^*+C_0)$  of firms to eliminate all their carbon emissions in the second period. Secondly, all firms in period 1, and a fraction  $1-G(C^*+C_0)$  of firms in period 2, have higher fossil fuel consumption than otherwise, due to lower of such fuels than otherwise.

Not much definitive can be said about this without further specifying model parameters. Consider, as a specific example, the Cobb-Douglas production function  $Y = E^\gamma$ , where  $\gamma$  is the factor share to energy for the set of firms in question. Assume that  $\alpha$  is unaffected by E (CDM approval is independent of project size). The overall increase in fossil energy use per firm due to the under-taxing of emissions from such fuels is then approximately, in the current case of CDM opportunities, as compared to the case without:

$$(16) \quad \Delta E_1 = \frac{q}{h + D - \alpha q \frac{G(C^*+C_0)}{2 - G(C^*+C_0)}} \frac{\alpha}{1 - \gamma} G(C^*+C_0) E_0,$$

where  $E_0$  denotes energy use per firm per period in the case with no CDM possibilities.<sup>11</sup> The reduction in fossil energy use, on average per firm, due to switches to renewable energy is<sup>12</sup>

$$(17) \quad \Delta E_2 = \alpha G(C^*+C_0) E_0.$$

In (16), the first fraction on the right-hand side is the ratio of the emissions quota price to the effective energy cost facing firms. This ratio is likely to be less than unity (perhaps substantially less), at least as long as the quota price  $q$  is low (substantially lower than the sum

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<sup>10</sup> As noted above, if host countries are under-controlling local pollution externalities then there is a pre-existing distortion of the fossil fuel price, to which the strategic response to CDM adds. We consider this case below.

<sup>11</sup> This formula is strictly correct only when the change in E, in response to a lower carbon tax, is marginal. This is likely to be “more correct” when  $G(C^*)$  is small, as the government’s optimal “tax correction” is then small.

<sup>12</sup> It is here assumed that all technology switches in period 2 are due to the CDM. This need of course not be the case, in particular not when  $b + \beta D < h + D$  (so that in the absence of the CDM the effective fuel price facing firms would be lower when using renewables than when using fossil fuels). This would in case lead to a second, strictly positive, cut-off point for firms’ retrofit cost,  $C^{**}$  ( $< C^*$ ), below which firms would always make the switch in period 2. Only a fraction  $G(C^*+C_0) - G(C^{**})$  of firms would then switch as a consequence of the CDM. The reduction in fossil energy use resulting from the CDM, in (17) would be correspondingly smaller. As a result, the “incentivized” increase in fossil fuel consumption would be greater as a share of the “incentivized” reduction, compared to the calculations carried out here.

of the basic energy price  $h$  plus the local environmental cost  $D$ ).<sup>13</sup>  $\gamma$  is the factor share of energy in production, which for energy-intensive firms is likely to lie in the range of 0.1 to 0.5 (with the upper level for electricity sector firms). Thus  $1/(1-\gamma)$  is likely to lie in the range 1.1 to 2; but its average value for the entire economy is much closer to unity than to 2.

Consider the energy- and emissions-market situation currently existing (as of March 2010), with an oil price ( $h$ ) of 70 dollars per barrel, and an emissions price in the EU-ETS ( $q$ ) of about 12.50 euros (US\$17) per ton CO<sub>2</sub>. Assume also that the sum of the last two terms in the first denominator of (16) is negligible, and that  $\gamma = 0.25$  (as an average for all firms seeking CDM approval in the relevant economy).<sup>14</sup> In this case,  $\Delta E_1 \approx 0.16\Delta E_2$ : the rate of “leakage” (in terms of excessive general fossil-fuel consumption due to the general energy subsidy) is slightly less than one sixth.

This should lead one to the conclusion that in most likely cases  $\Delta E_2$  is greater than  $\Delta E_1$ , so that the CDM together with its induced policies leads to an economy-wide reduction in fossil fuel consumption and carbon emissions. Indeed, a different result would be highly surprising.

Note however that if quota prices were far higher, this relationship could in principle be reversed. Retaining other parameters in (16), how high must the quota price,  $q$ , be in order to make  $\Delta E_1$  greater than  $\Delta E_2$ ? We find that the condition is  $q > \text{US\$}105$  per ton CO<sub>2</sub>. This is, admittedly, a high offset price, and unrealistic for the foreseeable future.<sup>15</sup> It however alerts us to a future problem that might become more severe if future offset prices increase substantially, given the current structure of the offset market.

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<sup>13</sup> I will stress here that  $D$  is not related mainly to carbon emissions; but rather to other local externalities. In the case of renewable energy, note also the assumption that while some fraction  $\beta$  of local externalities remains, such energy is assumed to emit no carbon. An obvious example would be where (carbon neutral) biofuels are used for powering vehicles that cause other externalities, such as road congestion, road wear and accidents, which are basically unaltered by the fuel switch.

<sup>14</sup> Note here that burning one barrel of oil releases approximately one half ton of CO<sub>2</sub>.

<sup>15</sup> Note however that if the main fossil fuel in question instead were coal, with a higher carbon content relative to its commercial value, this optimal price would be lower. Note also e.g. that the Stern Review (Stern 2007) indicates a social cost of carbon of about US\$85/ton CO<sub>2</sub> along the “business-as-usual” path (where the current regime, with a climate policy effectively only in the EU, is arguably very close to such a path).

How large is the “tax subsidy element” embedded in  $s_1$ ? To illustrate this, consider first the main example for  $q$  above ( $= h/6$ ). Assume now further that  $\alpha$  is constant and equals  $1/2$  (the probability of obtaining CDM approval for a given firm seeking such approval equals one half), that  $D = 0$  (no local environmental damage), and  $G(C^* + C_0) = 1/2$ , thus  $G(C^* + C_0)/[2 - G(C^* + C_0)] = 1/3$  (half of all “CDM-eligible” firms have sufficiently low retrofit costs to implement a CDM project). In this case there is no tax on  $E$  (since  $D = 0$ ):  $s_2 = 0$ . In this example find that  $s_1 = -(1/36)h$ : fossil energy is *subsidized* by the local government, but at a rather low rate, equal to  $1/36$  of the basic energy price.

This example is special as it involves no local damage from energy/fuel consumption. My main point here is not to show that it is necessarily optimal for the host government to subsidize energy; instead the idea is to demonstrate a tendency for the energy tax to be set, or kept, below the level of local marginal damage cost,  $D$ .

My example indicates that the degree of under-taxing could be small. But this does not mean that the CDM has little distortive effect on fossil fuel consumption. Because the “base” is likely to be much larger for the fossil fuel tax than for the CDM credit, the overall effect of under-taxing on carbon emissions could still be large relative to the carbon emissions saved directly from the implemented CDM projects.

### 3.2 Zero Environmental Taxes

I will in this and the next sub-section consider two cases that are alternative to the case of “optimal” emissions taxes treated so far, and start with the case of zero environmental taxes. This may be a relevant benchmark case in describing actual government behavior. In this case the solutions for  $B$  and  $E$  are given directly from (3) and (5); neither variable is affected by policy (or rather the lack thereof). The only relevant policy variable is  $C_0$ . From (8) and (12), we have



$$(18) \quad C_0 = D(E - \beta B)$$

Now the (constrained) optimal subsidy to the renewable technology simply equals the overall (local) environmental impact per firm of fossil fuel consumption for firms relying on such fuels, minus the overall impact of renewables consumption for firms relying on this type of fuels. Intuitively, this difference is now at the same time the difference between degrees of under-taxing of the two fuels. Such under-taxing should optimally be counteracted by a direct subsidy to the renewables switch.

### 3.3 Globally Optimal Carbon Taxes

Consider next a case where the government in question imposes a locally optimal tax on renewable energy vis-a-vis the CDM, given by (13), but where the unit fossil fuel tax is now required to be “globally optimal”, namely,  $D + Q$ , where  $D$  as before is the local externality caused by fossil fuels, and  $Q$  is the global externality caused by carbon emissions from such fuels.<sup>16</sup> The first-order condition for firms’ use of fossil fuels is in this case:

$$(19) \quad pf'(E(t)) = h + D + Q$$

Given that  $Q > 0$ , this obviously leads to a lower level of fossil fuel use  $E$ , than what was found in subsection 3.1 above. But perhaps more significantly here, it also affects the government’s (constrained) optimal subsidy to the renewable technology. Assuming that the renewables tax is still optimal and given by (3), the optimal level of  $C_0$  is found as

$$(20) \quad C_0 = -QE.$$

The carbon tax here “disturbs the playing field” by overly favoring the renewable source in the firm’s choice between the fossil and renewable energy sources in period 2, as this choice

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<sup>16</sup> Perhaps more realistically here,  $Q$  would be set such that the sum of the “carbon tax”  $Q$  and the offset price  $q$  together equal the global carbon externality, assuming that the offset price  $q$  falls short of embedding the full global externality. OECD (2008) describes, and deems as realistic, combined uses of taxes and cap instruments, and points out that, typically, an increase in the emissions tax will lead to an equivalent reduction in the emissions trading price, and vice versa. Such an interpretation would not affect the fundamental argument in this section.

is viewed by the firm's government in setting policy. This is "adjusted back" through a tax on establishing the renewable technology.

This case may seem not very relevant, as one may argue that required emissions taxes are likely not to exist in countries hosting offset projects. Nevertheless, the analysis illustrates that an expanding system of international carbon taxation would be less powerful for influencing technological switch to renewable energy when an offset market also is available. In this example, the extra carbon tax does nothing to favor the renewable technology in period 2, as this effect is fully "undone" through opposite tax or subsidy adjustments by the host government. There is however an effect of such taxation, possibly substantial, on fossil fuel consumption and carbon emissions, for firms based on fossil fuels.

#### **4. Conclusions and Possible Extensions**

I have in this note discussed incentives for governments of host countries for CDM projects, to modify their environmental policies so as to enhance the profitability and attractiveness of domestic CDM projects. We find that host governments are likely to do this in two distinct ways. First, by *selecting more lax general environmental policies than otherwise*, by keeping taxes on fossil fuels below levels they would otherwise have incentives to set (or even, in some cases, subsidize such fuels). The overall effect is to increase the country's fossil fuel energy use "across the board", to a higher level than otherwise, in all firms that do not currently exploit the CDM mechanism. The driving force behind this policy modification is that some of these firms are likely to later seek CDM financing. When they do, the higher initial fossil energy consumption levels, induced by these general government policies, is a favorable feature as they permit a greater reduction in emissions later, when the CDM projects are then implemented.

The second policy modification is to *subsidize firms' use of alternative energies*, or switch from a fossil-based technology to one based on renewable energy. Such a subsidy is optimal since the first policy modification noticed, namely the under-taxation of fossil fuels, by itself leads to an excessive preference for the fossil fuel technology. If uncorrected, this factor would lead too few firms to switch to the renewable technology.

The model presented here is conceptually similar to Strand and Rosendahl (2009), except that in the latter paper, the strategic behavior in response to offset market possibilities was induced for *firms themselves*. Such “strategic baseline inflation” by project hosts could however, if discovered, be sanctioned by the EB; which may keep firms away from this form of “gaming” behavior. In our model, by contrast, any strategic response is by *the firms' host government*, through defining the policy environment in which firms operate. If firms simply behave rationally and maximize profits in response to such host government policies (and, without any specific concern for the CDM), it could make it more difficult to argue against CDM approval.

Another key difference from Strand and Rosendahl (2009) relates to the distribution of impacts of policy on fossil fuel consumption and carbon emissions. In the latter paper, an excessive fossil fuel consumption is induced by the existence of the CDM *only in those firms that seek CDM credits*. Here, the distortion is *across the board*, in the entire sector that consumes fossil fuels, and thus in possibly many more firms. The distortion is now smaller, and perhaps less noticeable, per unit of fossil fuel consumption, but it affects far more consumption.

Questions can be raised as to whether future offset possibilities actually, and perhaps unduly, interfere with the conduct of sound environmental policy in CDM host countries. It is first unlikely that any country would admit to a direct connection between the two. Such policy responses would be counter to the spirit and intention of the idea of offsets, which is to

aid the world to a better and less painful implementation of reductions in greenhouse gas emissions globally. It may here also perhaps be far-fetched to assume that governments directly engage in “gaming” behavior by deliberately making their environmental policies laxer than otherwise. The point of my model is however simply to identify some basic forces at work, that may affect the incentives of governments. The model may seem particularly applicable where the relevant government policy response is to *resist policy reforms in the direction of lower emissions*, relative to what might otherwise be achievable. Such incentives may in consequence serve as brakes to e.g. reducing pre-existing fossil fuel subsidies. Our model is probably less applicable to explaining reforms that directly *increase emissions* (such as the introduction of *new* policies for subsidizing fossil fuel consumption).

One further unrealistic aspect of the model needs mention, namely the assumption that the government incurs no cost related to the fiscal expenditure following from under-taxing. Given such costs, the optimal rate of under-taxing of fossil fuels, and direct financial support to renewables projects, are likely to be smaller than those derived here.

A few extensions are immediately obvious. I will mention the following.

- 1) A variant is to consider cases where a mitigation project (switching to renewable energy) is carried out only after CDM financing has been secured (or, more generally, after a signal indicates a higher than otherwise probability of CDM financing). In the current model, all firms with sufficiently low retrofit costs switch to renewable energy in period 2, regardless of whether or not they actually obtain CDM financing. This would give a smaller economy-wide effect on switching in the sense that firms without CDM projects would now never switch. The “signal” (or incentive to switch) would however be more powerful for firms with CDM project possibilities, and a larger share of these (a greater fraction of the distribution G) would actually do the switch.

- 2) I assume that all firms in period  $t$  establish with a technology to use fossil fuels. A more complete long-run model must however also more seriously address the initial establishment decision issue. In the context of my model, governments may conceivably have incentives to support the establishment of fossil fuel based firms, who later switch to renewable energy. This type of subsidy policy may however be farfetched as it runs more openly counter to the spirit of the idea of GHG offsets.
- 3) In this model firms are myopic in the sense that they do not adapt strategically to the CDM prospect; such “adaptation” is left to host governments (via the environmental tax policy). Similar adaptation by firms can probably take place in a number of subtle ways, which could be studied in future research.
- 4) One particular category of “CDM project” is directly considered in the paper, namely conversion from fossil fuels to renewable energy while the production structure is otherwise retained. As noted the model structure can easily be adapted to other types of retrofit including CCS implementation. Many other project types not dealt with here are however also relevant as CDM projects, including a) “dirty” project closedown; b) “clean” project start-up (with a presumption that this project replaces another, “dirty”, one); and c) “dirty” project scale down. While the analytical details would vary somewhat, the fundamental principle, that project host governments are given incentives to relax their environmental policies, would likely stand.
- 5) It could be argued that the main problem addressed in this paper, namely relaxation of environmental policies due to the CDM, only is a temporary problem, as it is likely to affect firms in a transition phase from “dirty” to “clean” production: Once these firms have reached the “clean” stage the policy distortion will no longer be a problem. The point then to stress here is that this “transition phase” can be long, and prolonged by rising values of the offset price,  $q$ , over time. With increasing  $q$  values, a government

may find it advantageous to let emissions increase to establish a high baseline for “later” periods with even higher quota prices. In this sense, rapidly rising offset prices could be particularly harmful for emissions in a transition period to a possible final steady state. Note here that the model can and should be expanded in the time dimension, by including rising values over time for various other parameters including  $h$  and  $b$ , and to changing values of the local environmental tax rates  $s_1$  and  $s_2$ ; and where firms exist for a larger (variable, and endogenous) number of periods.

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